



Additive Manufacturing/ 3D Printing

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Outline

- Additive Manufacturing (AM) deployment in sustainment
- Summary of the 'AM in Depots' Report To Congress
- AM technology advancements benefitting sustainment
- AM security advancements
- Implications of AM-based designs for the sustainment community



AM In Sustainment Today

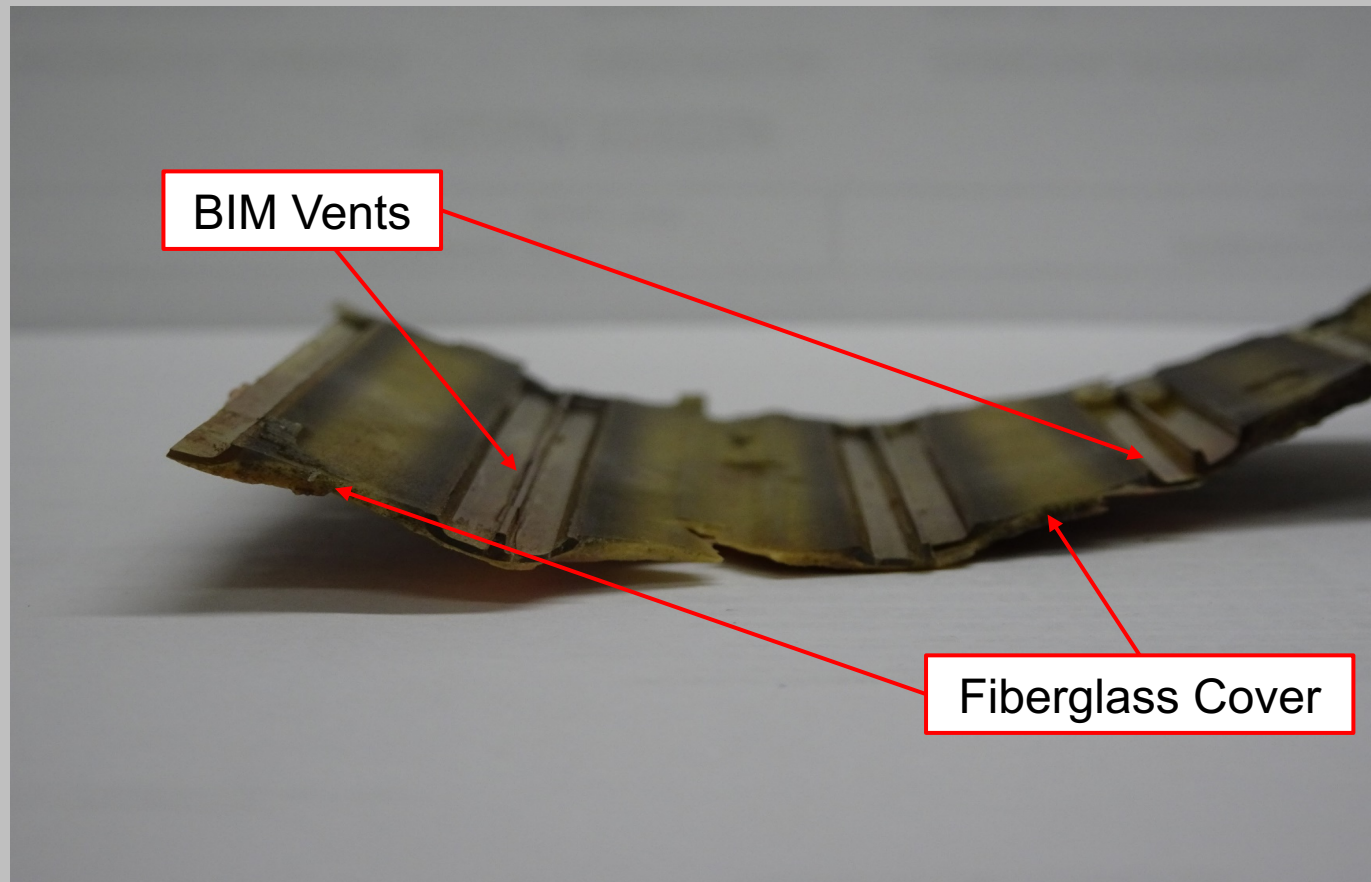
- **Army:** Developing an expeditionary rapid fabrication at the point of need for Brigade Support Battalions
- **Marine Corps and US Army Corps of Engineers:** Developing a 3D concrete printing capability for facility construction
- **Navy:** Pursuing the formal qualification and certification of parts for its rotary wing fleet
- **Air Force:** Printing F-15 pylon ribs to replace parts degraded due corrosion issues



<https://blog.grabcad.com/blog/2018/11/27/using-3d-printing-to-build-structures-and-self-sufficiency-in-the-navy-and-marine-corps/>

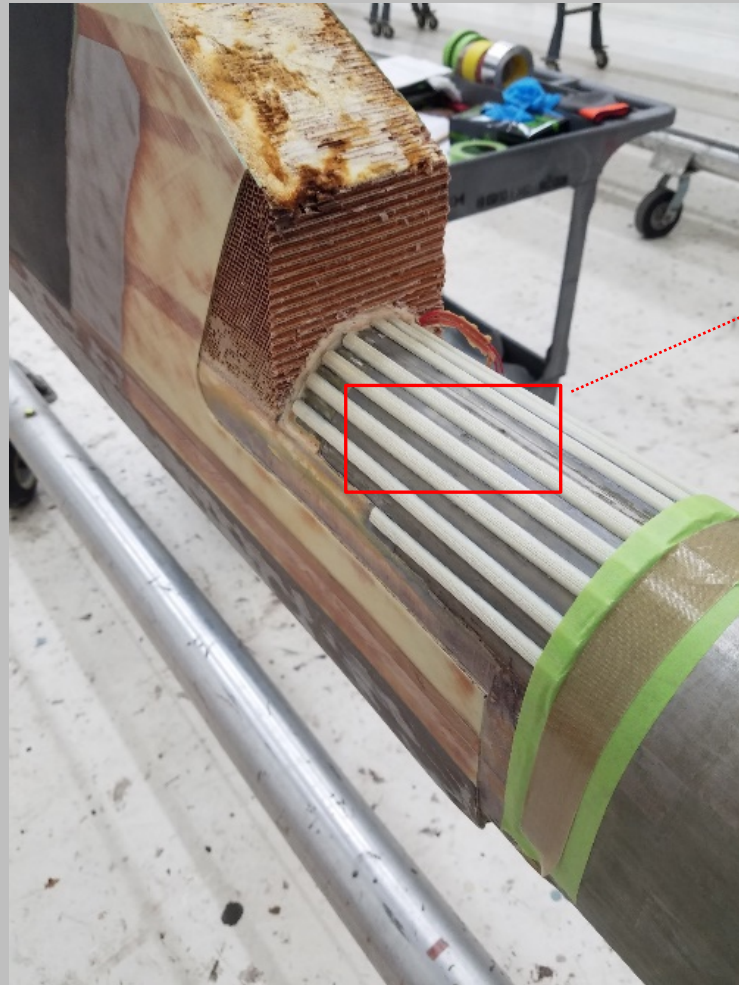


NAVAIR Case Study: H-53E Main Rotor Blade (MRB) Blade Inspection Method (BIM) Vent Repair





H-53E MRB BIM Vent Repair





H-53E MRB BIM Vent Repair

- **Cost Avoidance / Savings / Benefits**
- **FRC-E BIM Vent repair using AM parts**
 - ~\$15K per blade, 14-21 day Turn Around Time (TAT)
- **Re-pocket MRB at Original Equipment Manufacturer (OEM)**
 - \$210K per blade, 160 day TAT
- **\$195K savings per blade, \$1.26M per blade set**
- **139 day (~20 week) TAT reduction**
- **Added Benefits:**
 - First for using Polymer AM parts as Critical Application Item (CAI) components
 - BIM vent repair using AM unique within the DOD
 - FRC-E is now able to maintain a steady flow of MRB repair work through the Blade Shop
 - Reduce backordered repairs & F-condition stock at NAVSUP
 - Contribute to improvements in readiness posture for the fleet



Additive Manufacturing for DoD Depots Report to Congress

- **Benefits of AM in DoD depots - Improved materiel readiness due to:**
 - Increased speed of part production through rapid tooling and production of obsolete parts (materiel availability and mean down time)
 - Indirect AM applications such as fixtures, tooling and fit-checks to increase manufacturing speed and workforce efficiency
 - Production of end-use components to mitigate parts obsolescence, lower cost and shorter lead time
 - AM repair capabilities to restore damaged components to operational condition
- **Path from an identified need (repair or replacement part) to delivery of a verified part is complex**
 - Involves many steps, organizations, people and data exchange within a Service, across DoD components, and with Industry
- **Foundational challenges to integrate AM into depots:**
 - Alternate source approval processes
 - Need to convert depot infrastructure from paper based to digital
 - Secure data access and exchange
 - Validated and controlled materials and manufacturing processes
 - Qualified and trained personnel
 - Business framework to use AM and make logistics/supply chain decisions
- **AM Strategy for depots should address Alignment, Agility, Mitigation, Proficiency, Engagement, and Interoperability**



Strategy to Further Integrate Additive Manufacturing Capabilities into DoD Industrial Facilities

ALIGNMENT

AGILITY

MITIGATION

PROFICIENCY

ENGAGEMENT

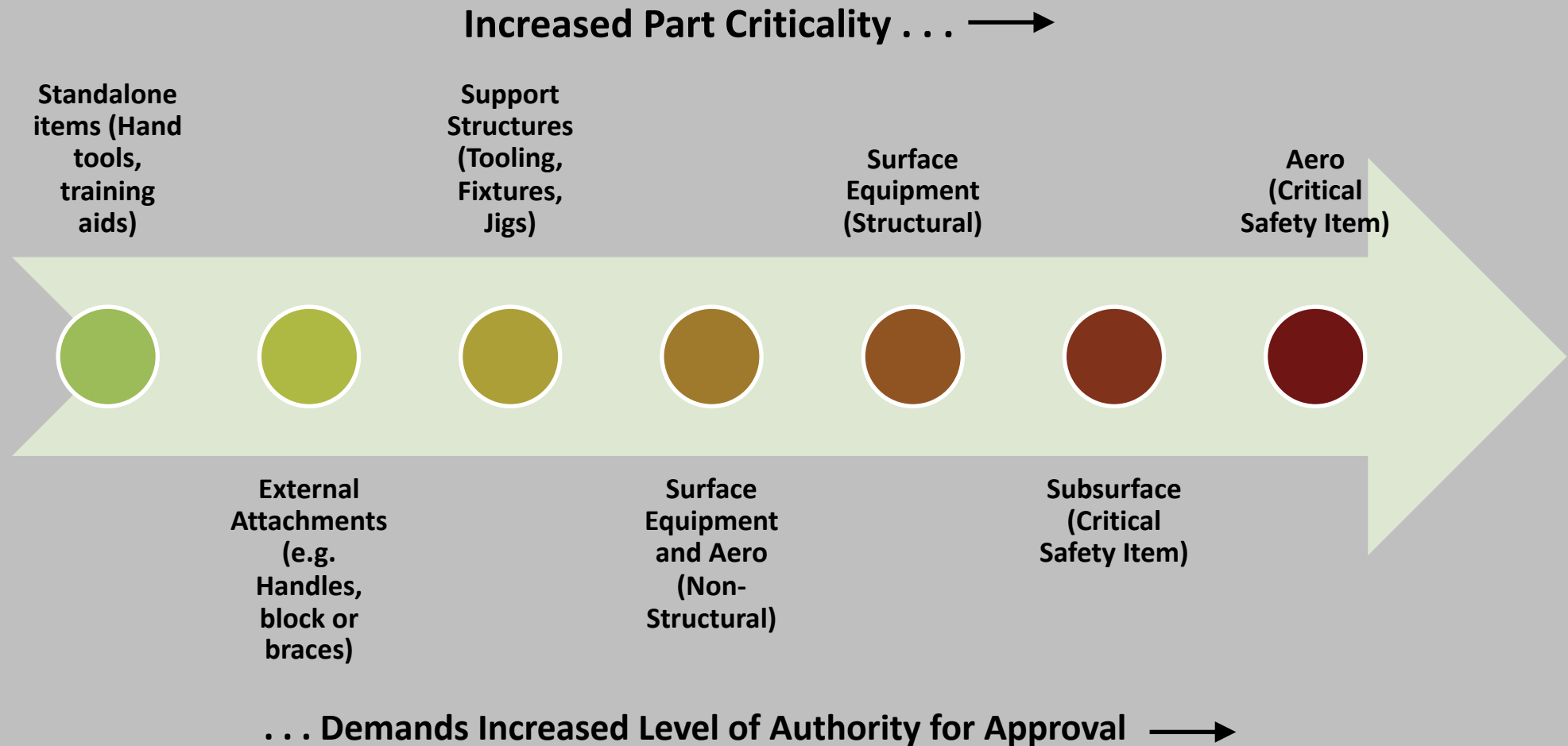
INTEROPERABILITY

To further integrate AM into industrial facilities DoD will pursue the following strategic goals:

1. **ALIGNMENT:** Align leadership and resources.
2. **AGILITY:** Be agile in the use of AM.
3. **MITIGATION:** Use risk management best practices.
4. **PROFICIENCY:** Develop internal expertise and share best practices.
5. **ENGAGEMENT:** Engage the commercial industrial base.
6. **INTEROPERABILITY:** Embed Joint solutions where possible.



DoD Risk Management for AM Parts - Notional Composite Summary



Note: This is a notional composite chart only, representing a cross-Service perspective based on each Service's criticality assessments for AM parts. This is intended to show a general categorization of parts and the increased level of risk, therefore increase level of authorization required. There will be variations based on the specific application, materials, etc.



DoD Depots with AM Capabilities

- **Army**

- AM Center of Excellence (COE) at Rock Island Arsenal Joint Manufacturing and Technology Center (RIA-JMTC); Letterkenny Army Depot; Watervliet Arsenal, Tobyhanna Army Depot; Pine Bluff Arsenal; Corpus Christi Army Depot; Anniston Army Depot

- **Navy**

- Public Shipyards – Norfolk VA, Pearl Harbor HI, Portsmouth ME, Puget Sound WA.
- Fleet Readiness Centers (FRC Southwest - San Diego, CA, FRC Southeast – Jacksonville, FL, FRC East – Cherry Point, NC)
- Regional Maintenance Centers

- **Marine Corps**

- Marine Corps Logistics Command – Marine Corps Logistics Base Albany, NY, Marine Corps Logistics Base Barstow, CA

- **Air Force**

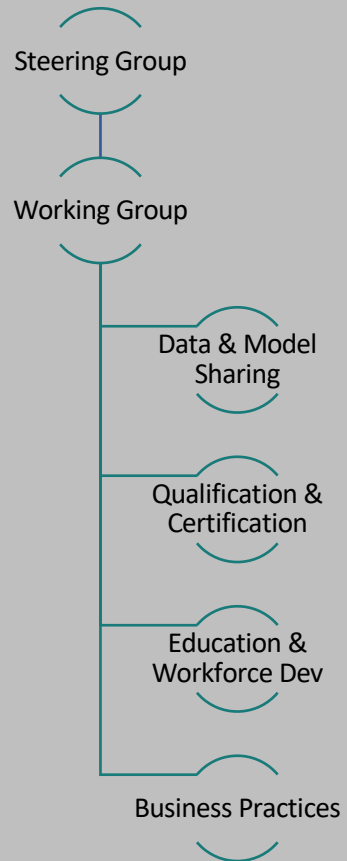
- Air Logistics (Depots) at Oklahoma City, Ogden, UT, and Warner Robins, GA
- Air Force Life Cycle Management Center (AFLCMC) Advanced Technical & Training Centers (ATTC) in Dayton, OH and Middle, GA
- Air Force Bases: Barksdale LA, Davis-Monthan AZ, Edwards CA, Elmendorf-Richardson AK, Keesler MS, Patrick FL, Sheppard TX, Tinker OK, Tyndall FL, and RAF Mildenhall UK



Joint Additive Manufacturing: DoD Overview

Working across the DoD Enterprise: Research & Engineering, Acquisition, Sustainment and Logistics

Organization:



Objectives:



Outcomes:



Opportunities:





America Makes

The National Additive Manufacturing Innovation Institute



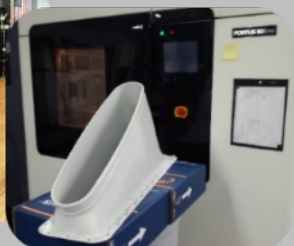
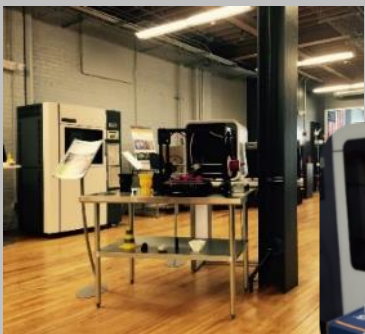
Established: August 2012

Hub Location: Youngstown, OH

Lead: National Center for Defense Manufacturing and Machining (NCDMM)



Mission: Accelerate the adoption of Additive Manufacturing (AM) in the United States industrial base to reduce cost, reduce lead time, and increase capability of DoD warfighter products.



TECHNOLOGY DEVELOPMENT

Since launching in 2012, America Makes has executed **over 75 projects** against a consortium developed AM technology roadmap. Projects range from those addressing design tools, materials, and processes to those supporting an integrated value chain.

DoD APPLICATIONS

America Makes delivered AM repair and replacement solutions along with training for DoD sustainment organizations to improve warfighter readiness. America Makes coordinated the AM community to prioritize and accelerate formation of standards and specifications critical to industry and organic DoD adoption of AM.

WORKFORCE READINESS

Application-based training programs were developed to fill a critical training gap for design and materials engineers to improve Design for AM (DfAM) skills. America Makes is developing the next generation of workforce training program to generate industry accepted labor certifications and credentials for DoD personnel.

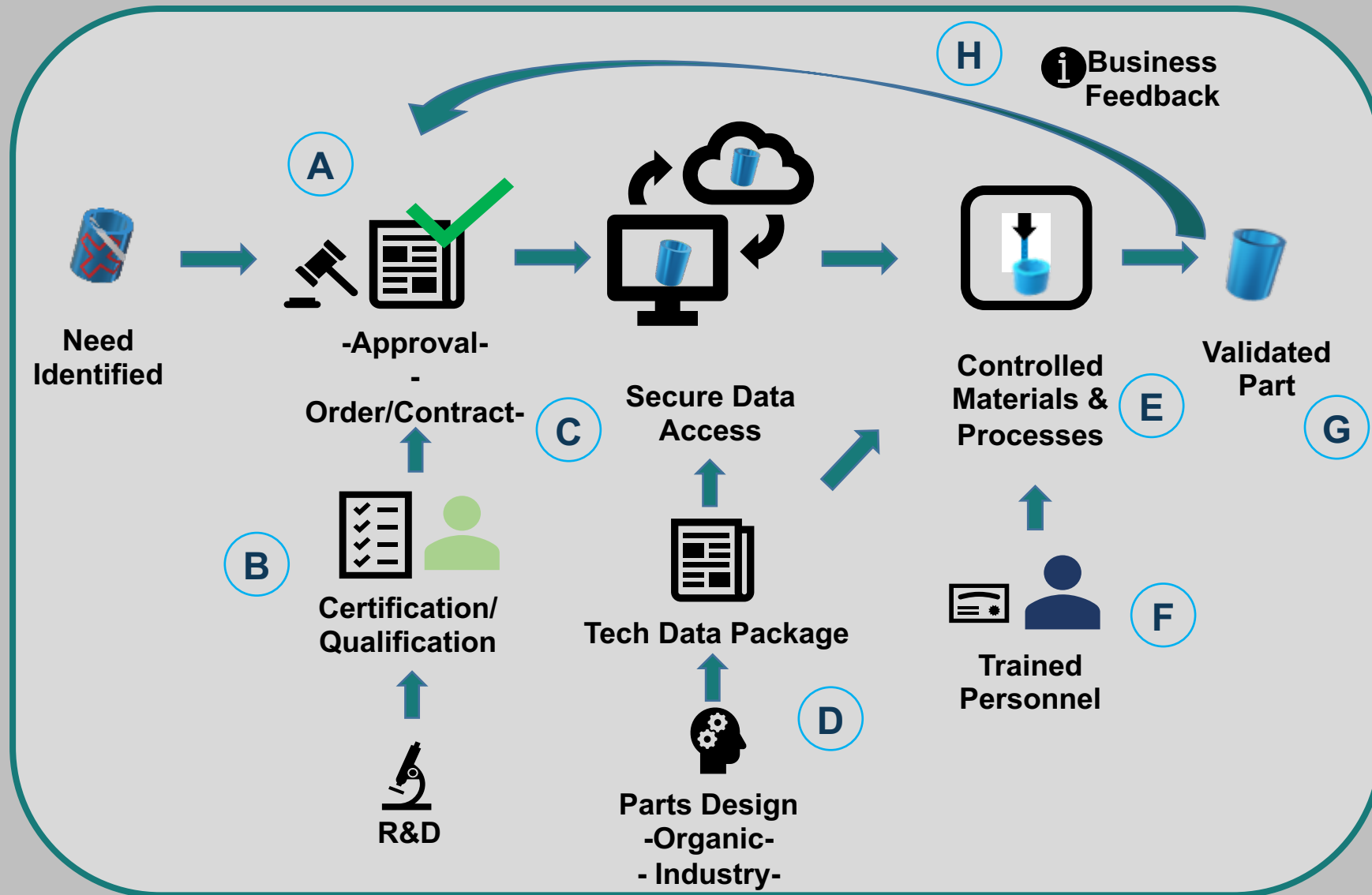
FACILITIES & CAPABILITIES

America Makes is an impartial **convener** of AM stakeholders, a **coordinator** of technical and workforce information, and an activation **catalyst** through the execution high-impact projects.

<http://americamakes.us/>



Additive Manufacturing: Opportunities for Technology Advancement





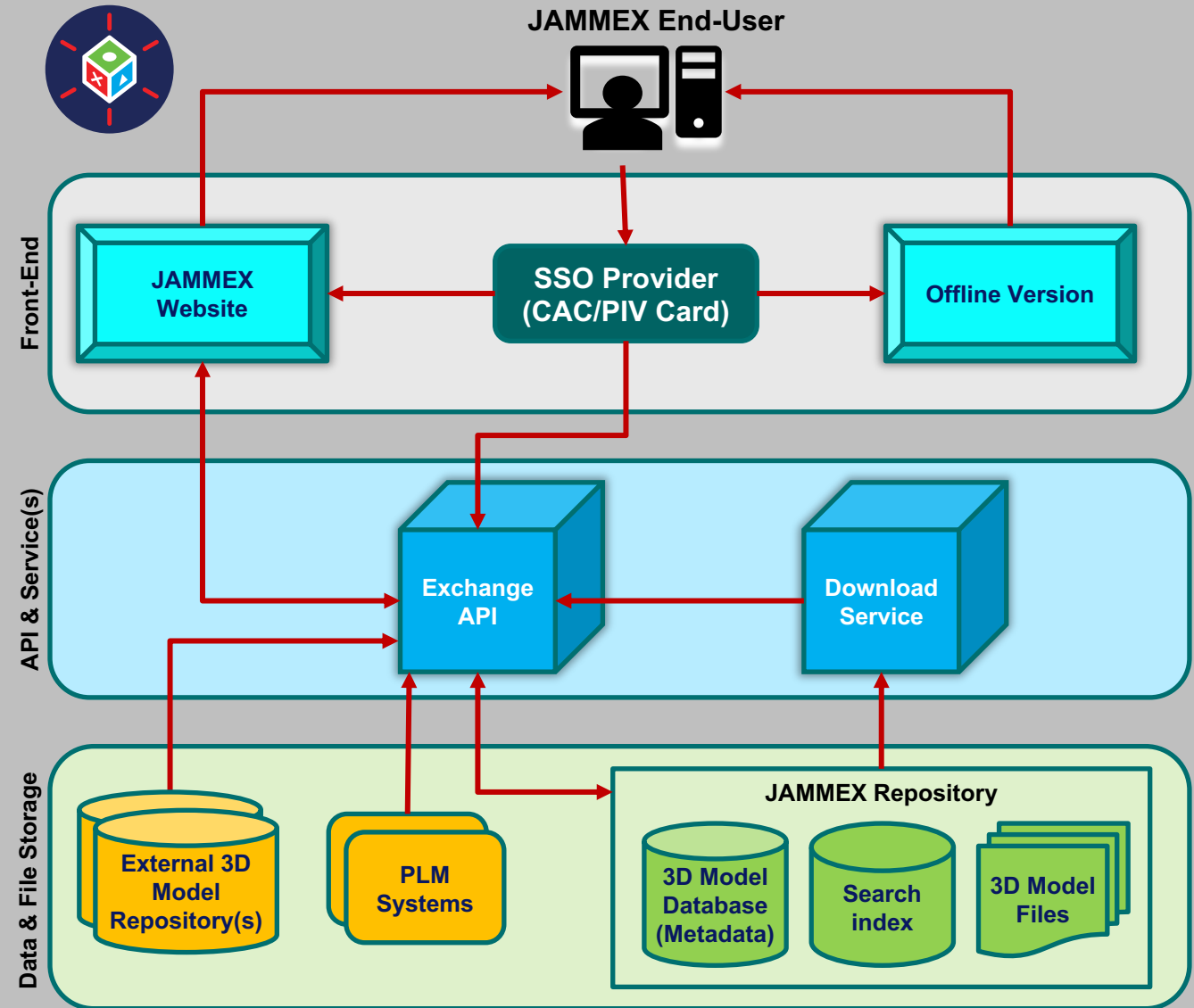
Joint Additive Manufacturing Model Exchange (JAMMEX) Architecture

JAMMEX will be configured to store the 3D model files and metadata in a dedicated repository for the models that are uploaded directly through the JAMMEX website or API.

3D models will also be available for accessing and downloading from separate data repositories, eliminating the need to migrate all content to JAMMEX.

Key components of the JAMMEX architecture include:

- **JAMMEX Website:** Primary place for users to find & locate 3D models
- **Exchange API:** Used to facilitate integration with other systems within DoD (import & export)
- **Download Service:** Used to offer downloads for large files
- **Offline Version:** Simplified website designed to be run off a local hard drive for low-bandwidth users
- **SSO Provider:** Single sign-on implemented for authentication with CAC/PIV cards



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Maturation of Advanced Manufacturing for Low-Cost Sustainment (MAMLS) Program Phases

LESS CHALLENGING RESEARCH APPLICATIONS



	CY 2016	CY 2017	CY 2018	CY 2019	CY 2020
Phase 1: “Low Hanging Fruit” - Tooling; reverse engineering; organic sustainment applications; business case development; and OEM supply chain activities. (broad-based sustainment support activities)	★ 8 Feb 2016 Phase 1 Award date \$8.99M (FY15 CII funding)				
Phase 2: “Qualification Pathfinding for Direct Part Replacement” - Direct part replacement research; tech gap ID; qualification issues; material issues; business cases; etc. (focused OEM component demos for feasibility studies)		★ 9 May 2017 Phase 2 Award date \$9.056M (FY16 CII funding)			
Phase 3: Rapid Transition & New Start Research Topics - Feature-based Qualification Using DED Understanding AM Mfg Realities Emerging Technologies for Low-criticality Part Families			★ 23 Apr 2018 Phase 3 Award date \$9.0M (FY17 CII funding)		
TOTAL FEDERAL FUNDING (\$)					\$27M

MORE CHALLENGING RESEARCH APPLICATIONS

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DoD Research and Engineering Enterprise

Solving Problems Today – Designing Solutions for Tomorrow



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